Perspective

Does Chemistry have a future?

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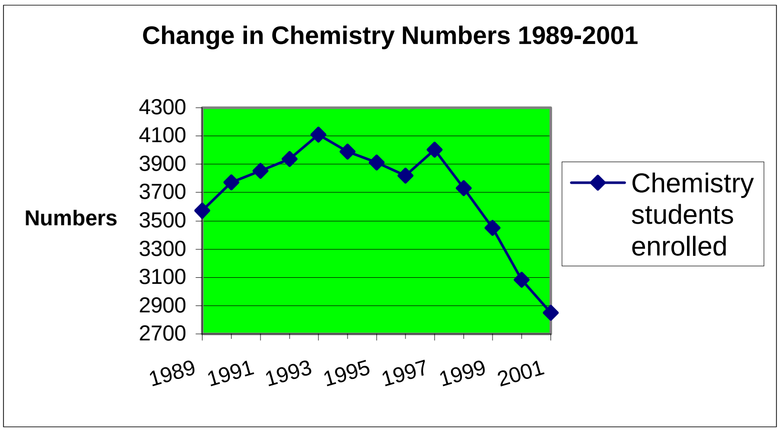
On 22 January 2002 a meeting was held at Lancaster University under the sponsorship of the RSC to address this question. It was attended by many Directors of Undergraduate Study from universities all around Britain, all concerned with the continuing struggle to maintain student numbers in our undergraduate chemistry courses. In fact this is not a peculiarly British problem; most other developed countries are experiencing the same difficulties. The purpose of the meeting was to examine the current position in detail and, if possible, to recommend strategies that may help in recruitment to the entire sector. The reflections that follow are personal views prompted in part by those discussions.

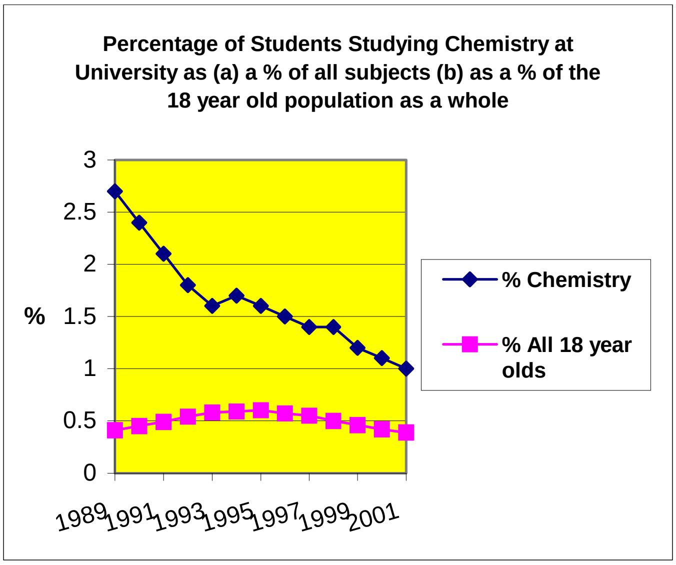
Figure 1



The current position

If we examine the change in undergraduate numbers enrolled on chemistry courses in UK universities over the past 13 years[1] (Figure 1), we see that the numbers were rising up to the mid-1990s, but the main, worrying trend has been the steady decline since 1997. It was this that started the alarm bells ringing in universities and departments and accelerated the process of closing or merging smaller departments unable to fill their places with well- or at least adequately qualified student entrants. How justified is this concern? Are we looking at the end of Chemistry as we know it or only as we used to know it, and do we have to look afresh at what we are offering to more diverse types of students?

Figure 2



There is another way of looking at recruitment, not just at absolute numbers, but taking account of the demographics as well.[1] Figure 2 shows some interesting data. While chemistry students represent a steadily declining proportion of the total student population, as a proportion of the whole age group the picture is a little different. There is a similar shape to the curve in Figure 1, but from it we are no more justified now in concluding that the past six years' figures indicate an inexorable decline than to have said in 1995 that the previous six indicate a gratifying and sustainable rise. Comparative data for other physical science and engineering courses and for biology over the same period suggests, after a general rise in the early1990s, a more or less steady level of admissions with some fluctuations from year to year. In short, the apparent decline in student numbers can be largely accounted for by the growth of the numbers of students studying other, non-science disciplines. Why Chemistry numbers are not growing at the same rate is a different, if no less important, question. An understanding of the reasons for this may take us further towards finding a way to reverse this trend and thus ensure a secure future for our departments and ourselves.

Why does Chemistry lag behind in the popularity stakes?

Possible reasons include the perceived intrinsic difficulty of the subject, the negative public image of the discipline, the unattractive character of the apparent 'obvious' career, and the lack of 'glamour' in the preoccupations of chemistry and chemists as compared to, say, people in the biomedical or environmental fields. The list is not complete. Let us examine the various issues in turn.

'Chemistry is difficult'

This is a widely held view, both in the secondary and the tertiary sector, especially amongst students who have to take it because of the demands of the professions or degree schemes they really wish to follow. Whatever we think of it, many sixth-formers experience the demands of chemistry and move away from it when making their choices of university courses. Chemistry courses certainly demand more attention to be given to a greater diversity of activities and skills (literacy, numeracy, experimental skills) than many others, particularly outside the sciences, while apparently denying students the opportunity to be creative and hold and express their opinions on issues under discussion. The nature of the discipline is such that in the early stages, when the fundamentals are taught, the answers all seem to be known and it is just a matter of mastering the knowledge and reproducing it on demand. The live issues, the diverse and exciting applications still under investigation, only come before the students long after they had to make the decision to follow the path to chemistry. In addition, pressures on time and resources often mean that students get very little opportunity in the early years to experience meaningful laboratory work and gain an appreciation of chemistry as a living science rather than a dry theoretical subject. Changes in curriculum structure and organisation at the school level and context-based teaching are coming in slowly, but not fast enough to change attitudes fundamentally.

The negative image of the discipline

In the UK media the word 'chemical' has acquired a uniformly unpleasant connotation. (In Lancaster a house was advertised for sale recently with the major selling point of having a 'chemical-free garden'.) 'Chemical' almost automatically carries with it the adjective 'dangerous', whether because of toxicity, flammability or some adverse effects on the environment. One hardly ever sees penicillin or vitamin C described as a chemical. The association in the public mind with danger, pollution or some other menace is almost inevitable. People teaching chemistry at all levels, but particularly in schools where they have the opportunity to influence the entire age group, need to try to counteract this image, but it is an uphill struggle. The RSC could be more vigorous in promoting a positive image, but this will have to be done very carefully to avoid its efforts being dismissed as special pleading.

Career prospects

For far too many people the employment prospects for a chemistry graduate are represented by a white coat and a bench with glassware on it. The reality couldn't be more different. A survey[2] of about 2500 chemistry graduates leaving UK universities in 2000 (an 85 % response from 2882 graduates) revealed that just under half went directly into employment and about a third pursued further study, some towards a teaching career, but the majority towards a higher degree. Of those entering employment directly after graduation, about a quarter went into scientific research, analysis or development-based occupations, with the remainder spread around the widest range of possibilities encompassing IT, finance, other commercial or management, health or other occupations. Clearly, when it comes to employability, chemistry or the broad training it offers is widely seen by employers in many fields as being of value. The salaries offered to chemists are much the same as those offered to other graduates. The problem is to make this situation widely known to sixth formers when they make their subject choices. It is difficult to 'sell' our courses by saying, "*Come and study chemistry and afterwards you will be able to do anything else*", although the reality is exactly that. We know that a good degree in chemistry is a broad education as well as the foundation of a rewarding professional career, but how do we get this across to the public at large?

Unglamorous chemistry

Fashions change in science much more slowly than in clothes, but they do change. A few decades ago the physical sciences represented the pinnacle of ambition for a budding scientist. More recently developed concerns about the environment and the dramatic growth in our understanding of living systems means that now molecular biology, biochemistry, environmental chemistry and forensic science are the areas that excite young (and not so young) people. This is partly because of the possibilities for greatly enhanced understanding opening up through new techniques, but also because they represent areas of science where altruistic ambitions can find full expression. The idealism of the young is excited by the prospect of curing disease, of feeding the hungry and of protecting the biosphere. Of course, **we** know that chemistry enables them to do all those things, but that is not widely recognised. In vain do we protest that much of what is needed is the application of chemical knowledge either directly by the making of new drugs or ever more selective pest-control materials, or indirectly through the understanding of biological processes at the molecular level. These aspects have been 'cherry-picked' by colleagues in differently labelled disciplines; although their techniques and approaches are very often based on ours, they are perceived to be separate and different. These developments just reinforce the public image; when a new drug is synthesised and introduced into medical use, it is a great triumph for medicine or pharmacology, but when an intermediate for its manufacture is spilled because a tanker carrying it is involved in an accident, that is the spillage of a dangerous chemical. It is easy to become paranoid.

Another aspect of this is the nature of the problems being tackled by the different disciplines. Some of these are Big Problems, readily comprehended in their grandeur if not in their detail by the person in the street. The physicists have their cosmology: the nature, origins and mysteries of the universe reinforced by the stunning images from the Hubble telescope; the biologists, the rapidly growing knowledge about ourselves at the molecular level via the Human Genome Project, and other developments offering salvation from disease and the ravages of aging. Hardly a week goes by without the announcement of the identification of the gene for this or that quality or propensity.

Not only do chemists deal with matters that are difficult to express in such simple but high-sounding terms, but the discipline has reached a state of maturity where the broad outlines of its account of the world are there and likely to remain so. There is a tremendous amount of reliable knowledge now about the structure, properties and transformations of a wide range of molecules, and the theories we use to gain this understanding are quite good approximations. There will undoubtedly be new developments in the years to come, but these will be refinements on what already exists rather than fundamental revisions in the way that physics changed with the coming of quantum theory and relativity and biology changed with the development of molecular biology.

The best illustration for this can be found in the answers to the RSC's Scientific Forward Look for Chemistry.[3] A few years ago the RSC approached its divisions and subject groups with a number of questions concerning the likely major scientific innovations over the next 20 years, current hot topics, and what breakthroughs are needed to make significant moves forward. The answers are illuminating. They generally indicate that the expected developments will result in our doing what we are doing now, better, faster, with a much better understanding, with greater precision and in an environmentally more benign way. It is evolution, not revolution. No major problems were identified whose solutions were not implicit in our present knowledge and framework, if only we can get the details right. There are plenty of important matters and challenging problems, to be sure, but not sexy in a way that will attract a young person not already favourably disposed towards chemistry.

Does Chemistry have a future?

Of course it does. The real question is whether we can expect our student numbers to rise in parallel with those of the media studies and sports science courses or whether we should accept that chemistry is a specialised taste, not for everybody, and go for quality and not quantity. The debate within the profession is over the question of the purpose of university chemistry courses. In the blue corner are the traditionalists, recognising that there will continue to be a relatively small number of very able students who want to study chemistry because they love it and who will stay with it to provide the comparatively small number of specialist graduates needed for the survival of the profession. These could be taught successfully in fewer universities than are teaching chemistry at the moment. In the red corner are the reformers, who view a chemistry course as an excellent education for whatever subsequent career the graduate chooses to follow. Within this approach lies a greater emphasis on process and less on content in the undergraduate courses, with the high-level training required by the future professional being left to the post-graduate stage. Under this strategy, student recruitment should be maximised by whatever means to ensure that the greatest number will benefit from such high-quality education. Since a chemistry course is much more expensive to run than others in, for example, the humanities, the onus is on us to prove to our academic and political paymasters that the quality of 'the product' is correspondingly better. The market, in the form of starting salaries offered to new chemistry graduates, does not support that claim.

But this only deals with questions about 'pure' chemistry courses. Alongside is the continuing demand for chemistry and chemical knowledge in other disciplines. A case can be made for saying that chemistry is 'the mathematics of the natural sciences' in the following sense. In the physical sciences the topics being studied are matter and its properties, but the language in which the results are often expressed is that of mathematics. Properties, relationships, are often seen to be truly understood only when they can be expressed in mathematical terms in the form of an equation that fully and predictably describes them. In a similar way, many biological, geological (and of course biochemical) properties and relationships are explained and understood in chemical/molecular terms, even though the systems are too complex to be describable as 'only chemistry'. The descriptive chemistry used by our sister professions is only a small part of the total, but the principles underlying its use cover most of the important theoretical structure. Thus, chemistry will continue to be needed, even if sometimes masquerading under other names.

The meeting on 22 January did not produce magic solutions to solve the immediate recruitment problem; perhaps it was unrealistic to expect that it should. It may be that the tide will not turn and produce increased numbers of talented students applying for single honours chemistry programmes. Perhaps an additional, new breed of 'chemical science' type of course will need to proliferate in order to attract further students and produce many chemically literate graduates with no particular plans to enter the chemical profession. This course of action has to be approached with care, however, since we may be saying to prospective students, "*Come and study chemistry with us. It will open the doors to many professions for you, but unfortunately, not the door to chemistry*." Perhaps this is best done by institutions that can run both types of course side by side, with the possibility of transfer between them as the students' perceptions of their career choices evolve. It is a pity that for status reasons the Ordinary Degree has largely gone out of fashion; it could have provided a different, alternative route with a broader, less specialised educational profile.

Time will tell whether we shall be able to halt the drift of students away from chemistry, and it will be interesting to see how the curriculum will develop in order to attract the ever more choosy student. Watch this space.

Acknowledgments
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References

1. The data are based on that provided by the RSC at www.chemsoc.org/pdf/LearnNet/rsc/stats/3pop.pdf, and on information gleaned from UCAS, the UK's central organisation for the admission of students to universities.
2. http://www.prospects.ac.uk/student/cidd/wdgd/articles02/ed_science.htm
3. http://www.rsc.org/lap/polacts/forwardlookdocs.htm